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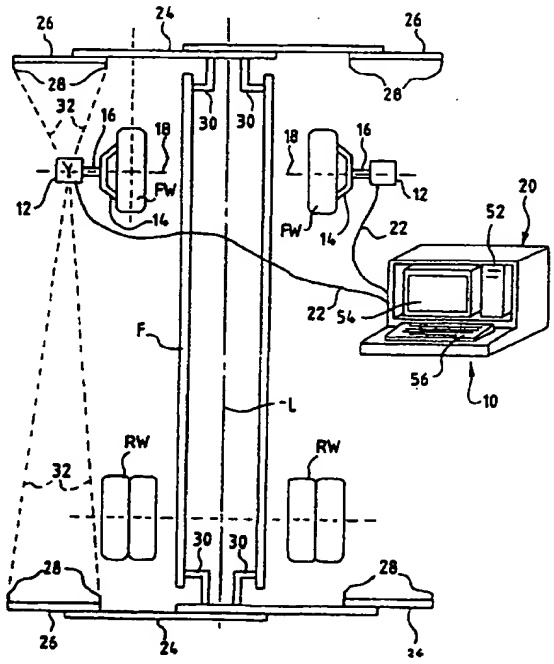
(54) Method of displaying vehicle wheel alignment conditions

(57) A method of displaying an alignment condition of a vehicle, comprising prestoring specifications for one or more wheel alignment conditions, prestoring a plurality of wheel graphics, each graphic corresponding to a difference between a measured wheel alignment condition and the specification for the wheel alignment condition, measuring the wheel alignment condition, determining the difference between the measured wheel alignment condition and the specification for the wheel alignment condition, selecting the graphic corresponding to the difference, and visually displaying the graphic.

FIG. 1



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Description

This application is based on U.S. Provisional Patent Application Serial No. 60/005,608 filed on October 19, 1995 and U.S. Provisional Patent Application Serial No. 60/005,720 filed on October 20, 1995.

Background of the Invention

The present invention relates to vehicle wheel aligners which may be adapted for use in performing alignments of non-standard or custom vehicles.

Existing wheel aligners comprise a number of sensors for generating data indicative of the relative orientations of the wheels of a vehicle, a computer for calculating alignment values from the data generated by the sensors and a video display for displaying the alignment values. Additionally, these aligners typically comprise a database of vehicle alignment specifications for a majority of vehicle makes and models. During operation, the computer calculates the alignment values for a subject vehicle and compares these values with the alignment specifications for that vehicle. The differences between the calculated alignment values and the specifications may then be displayed.

Summary of the Invention

According to the present invention, the aligner comprises a preprogrammed set of instructions for creating graphical representations of the alignment conditions of the vehicle based on measurements obtained both before and after adjustments have been made to the vehicle. The representations may be displayed to the operator during the alignment procedure to provide him a better understanding of the condition of the vehicle, and the representations may be printed out for presentation to the customer to evidence that the vehicle has been serviced properly.

Brief Description of the Drawings

Figure 1 is a representation of an exemplary wheel aligner in combination with which the present invention may be used;

Figure 2 is a representation of an angle measuring instrument employed in the wheel aligner of Figure 1;

Figure 3 is a flow diagram showing the sequence of steps undertaken to generate graphical representations of the conditions of the vehicle according to the present invention;

Figure 4A is a table showing the visualization rules which are used to produce the graphical representations;

Figure 4B is a table indexing the graphics referred to in Figure 4A with the representations shown in Figures 5A through 5G;

Figures 5A through 5G are exemplary displays of the graphical representations of a vehicle; and

Figures 6A through 6C are exemplary printouts of the graphical representations of a vehicle.

Detailed Description of the Preferred Embodiments

The present invention is primarily implemented through computer software, which can be readily recreated by the person of ordinary skill in the art by following this description. In addition, the invention may be incorporated into a variety of vehicle wheel aligners, but it is particularly useful with wheel aligners designed for use with trucks because of the existence of a great number of components requiring alignment in a truck. Therefore, for purposes of brevity the present invention will be described with reference to an exemplary truck aligner.

Referring to Figure 1, an exemplary truck aligner indicated generally by reference number 10, is shown in association with a truck which is represented by a frame F having a longitudinal axis L and a set of front wheels FW and rear wheels RW. Truck aligner 10 comprises one or more angle measuring heads 12, which are mountable to the wheels of the truck using appropriate wheel clamps 14. In Figure 1, a head 12 is shown mounted to each front wheel FW of the truck. Each wheel clamp 14 comprises a shaft 16 and suitable means for aligning shaft 16 with the axis of rotation 18 of the wheel to which it is connected, and the corresponding head 12 is pivotably mounted on shaft 16. Truck aligner 10 also comprises a console 20 to which heads 12 are connected through cables 22 or, alternatively, cordless data transceiver means.

Truck aligner 10 further comprises two frame gauges 24, which each include two scales 26 connected to the opposite ends of frame gauge 24. Each scale 26 in turn comprises a pair of reference marks 28 spaced a known distance from each other. Frame gauges 24 are mounted to opposite ends of frame F using suitable attachment devices 30 having appropriate biasing means for maintaining the same distance between longitudinal axis L and each pair of reference marks 28.

Each angle measuring head 12 operates to measure the angles between the axis of rotation 18 of the wheel on which it is mounted and the lines 32 extending to reference marks 28 on the same side of the truck. Referring to Figure 2, each head 12 is shown to comprise a light source 34, a collimating lens 36 for focusing the light into a thin beam 38 and a mirror 40 for reflecting beam 38 ninety degrees into an approximately horizontal plane. Mirror 40 is mounted on the shaft 42 of a motor 44, and rotation of mirror 40 by motor 44 causes beam 38 to rotate in the horizontal plane. A rotary encoder 46 mounted relative to shaft 16 continuously tracks the instantaneous angular position of shaft 42, and thus beam 38, with respect to shaft 16. Since shaft 16 is effectively aligned with the axis of rotation 18 of the wheel, encoder 46 measures the angle of beam 38 with respect to the

axis of rotation 18. Reference marks 28 on targets 26 are comprised of a retroreflective material, and as rotating beam 38 impinges on a reference mark 28, it will be reflected back to head 12 and received by a detector 48. The signals from encoder 46 and detector 48 are input into an appropriate logic circuit 50, which outputs data indicative of the angle of reference mark 28 relative to shaft 16. As beam 38 rotates through 360 degrees, data relating to the angles of the other three reference marks 28 on the same side of the truck is similarly produced. The data from each head 12 is transmitted over cables 22, or via cordless data transceiver means, to console 20.

Although not shown in the drawings, heads 12 may also include conventional inclinometers for measuring the orientations of the wheels with respect to known vertical reference planes to yield such information as the camber and caster angles of the wheels. The data generated by the inclinometers is transmitted to console 20 in a manner similar to that described above.

Referring again to Figure 1, console 20 is shown to comprise a programmable computer 52 for controlling the operation of truck aligner 10. In one mode of operation, computer 52 processes the data generated by heads 12 according to preprogrammed instructions and displays the alignment values for the truck on a monitor 54. A keyboard 56 is provided for entering instructions and vehicle information into computer 52. Computer 52 may also access programs and vehicle information through a floppy disk or CD ROM drive (not shown).

According to the present invention, computer 52 comprises a preprogrammed set of instructions for creating graphical representations of the alignment conditions of the vehicle based on measurements obtained both before and after adjustments have been made to the vehicle. Although for purposes of brevity and clarity the invention will be described with respect to the alignment of a truck, it should be understood that the principles of the invention apply to the alignment of many types of vehicles. The person of ordinary skill in the art will readily understand how the invention may be adapted for use with other types of vehicles.

According to the present invention, computer 52 is provided with a set of preprogrammed instructions which will generate video and print representations of the initial conditions of the axles of the vehicle both before and after adjustments are effected. Referring to Figure 3, the video and print representations are generated by first obtaining measurements of the initial vehicle alignment values and applying the measurements thus obtained to a set of predetermined visualization rules, which are shown in Figure 4A. Based on these rules, computer 52 generates the graphic and digital representations of the conditions of the axles. These representations are then displayed on monitor 54 and, at the operator's discretion, may be printed out on a standard printer. The vehicle is then adjusted and measurements of the alignment values are again obtained. Computer 52 applies these measurements to the set of visualization rules to generate graphic and digital representations of the final conditions of the axles, which may then be displayed on monitor 54 and/or printed by the printer.

As stated above, Figure 4A lists the visualization rules that computer 52 employs to generate the graphical representations of the vehicle The rules select predetermined graphics based on the amount the measured alignment condition differs from the preferred specifications for the alignment condition. Thus, computer 52 will compare the measured alignment condition with the specifications and select one of the predetermined graphics depending on the difference. For example, if the absolute value of the measured toe, or ABS (Toe), for a subject wheel is different from the specification by less than 1.5 millimeters per meter, computer 52 will display the Straight Graphics Position graphic for the wheel. Similarly, if the measured Toe Out for a subject wheel is greater than 1.5 mm/m and less than 3.0 mm/m, the computer will select the Toe Out Graphics Position 1 graphic for the wheel. It should be understood that visualization rules for other components of a vehicle may be created in a similar fashion, and that any number of predetermined graphics may be employed in the visualization rules.

Based on the graphic which the computer selects for each component of the vehicle, the computer will generate a graphical representation of the vehicle. This graphical representation will then be shown on monitor 54 to help the operator understand the alignment condition of the vehicle. In the exemplary truck aligner embodiment, the computer will apply the visualization rules to select a graphic for each axle, which usually includes two wheel sets and a connecting axle. The graphics referred to in Figure 4A are illustrated in Figures 5A through 5G, which are exemplary displays that may appear on monitor 54, depending on the measured alignment condition of a vehicle. For purposes of this description, Figure 4B references the graphics presented in Figures 5A through 5G to the graphics positions designated in Figure 4A. Thus, to view an exemplary Toe Out Graphics Position 1 graphic, reference may be made to the left wheel of the axle shown in Figure 2. Finally, Figures 6A through 6C illustrate exemplary printouts obtainable from the present invention.

Thus, the operator is provided with a visual representation of the conditions of the axles before he performs the alignment adjustments. This illustration of the initial condition of the vehicle may be presented to the customer as evidence that the vehicle does indeed require service. Furthermore, the operator is provided with a visual representation of the conditions of the axles after the operator performs the alignment adjustments. This enables the operator to determine whether the alignment has been performed properly. In addition, the illustration for the final condition of the vehicle may be presented to the customer as evidence that an alignment has been performed.

It should be recognized that, while the present invention has been described in relation to the preferred embodiments thereof, those skilled in the art may develop a wide variation of structural details without departing from the principles of the invention. Therefore, the appended claims are to be construed to cover all equivalents falling within the true scope and spirit of the invention.

Claims

1. A method of displaying an alignment condition of a vehicle, comprising:

   prestoring specifications for one or more wheel alignment conditions;
   prestoring a plurality of wheel graphics; each graphic corresponding to a difference between a measured wheel alignment condition and the specification for the wheel alignment condition;
   measuring the wheel alignment condition;
   determining the difference between the measured wheel alignment condition and the specification for the wheel alignment condition;
   selecting the graphic corresponding to the difference; and
   visually displaying the graphic.

FIG. 1

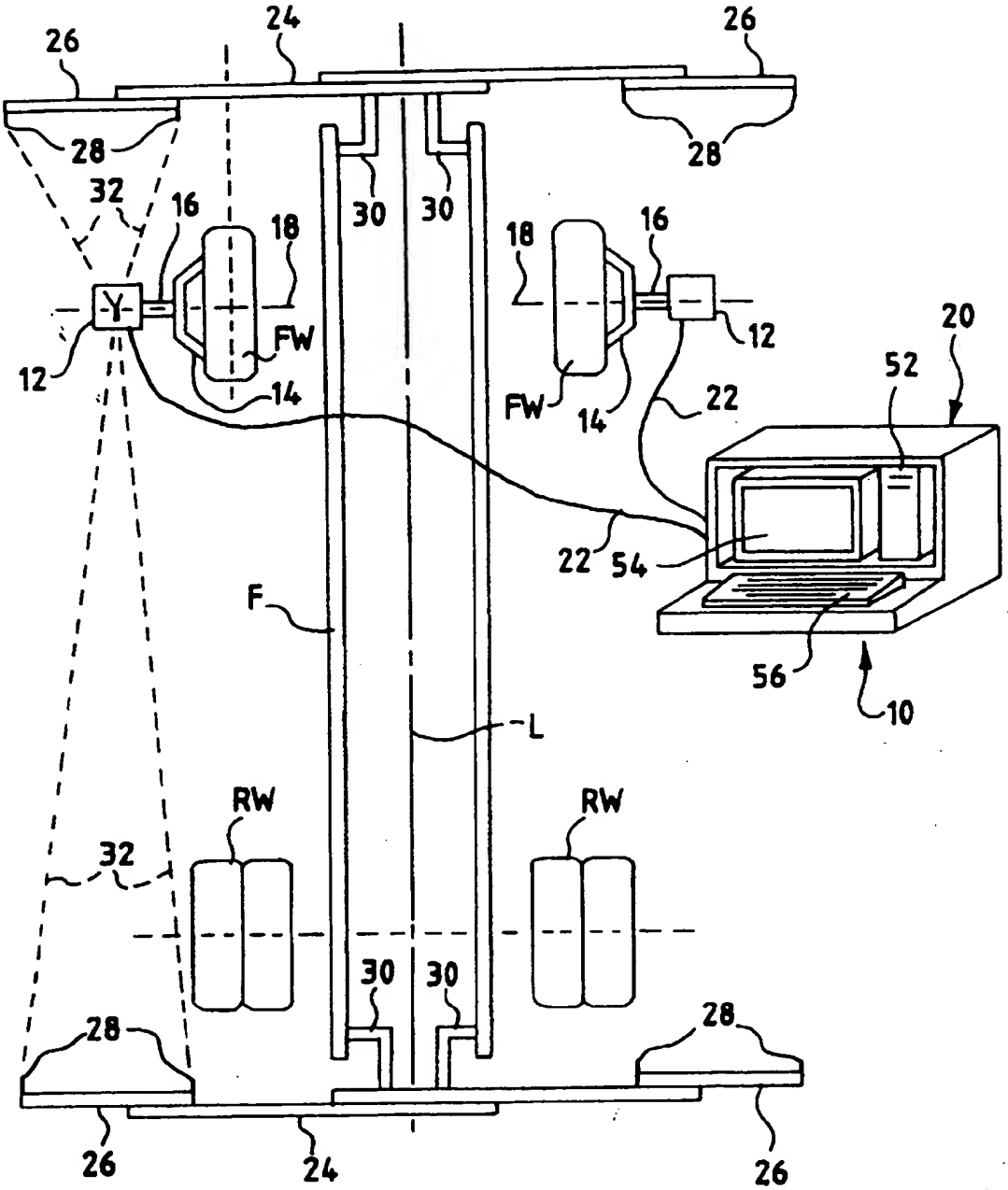

24
26
26
28
28
32
16
18
30
30
18
16
12
FW
12
14
FW
14
22
20
52
22
54
F
56
10
L
RW
RW
32
30
30
28
28
26
24
26

FIG. 2

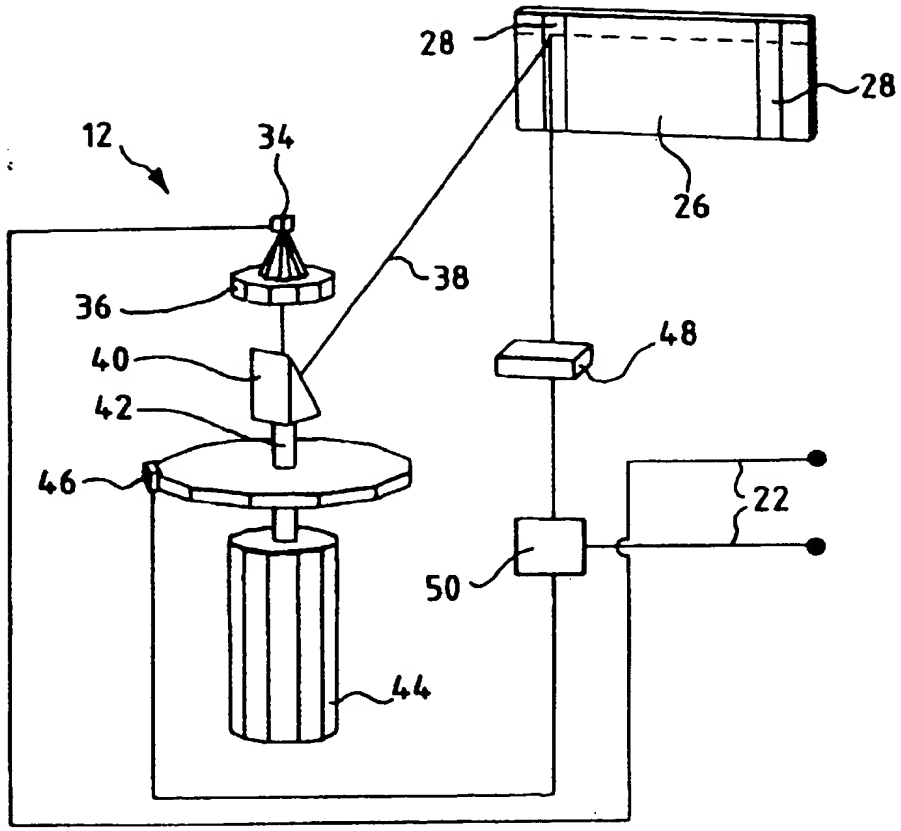


FIG. 3

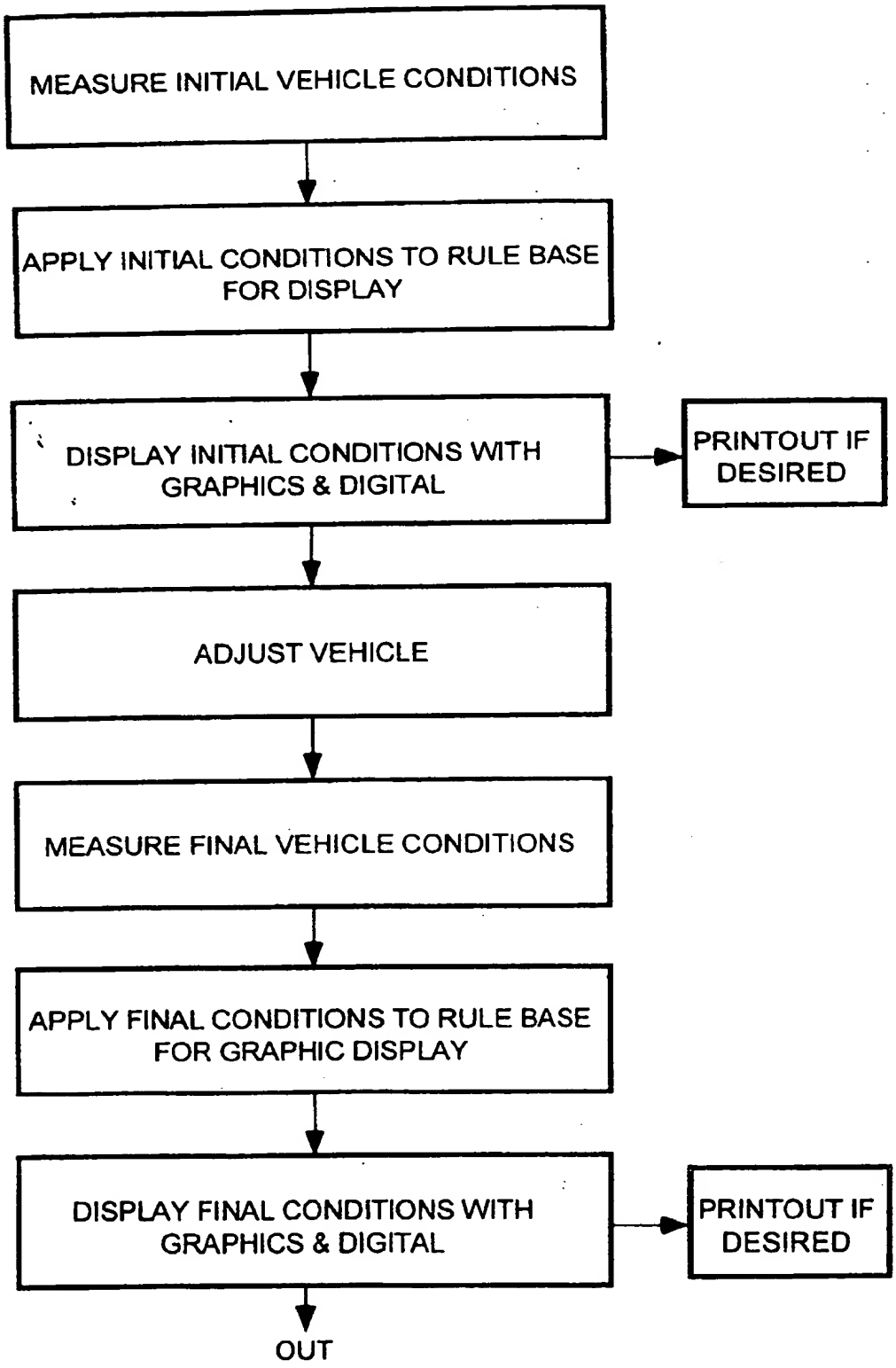

MEASURE INITIAL VEHICLE CONDITIONS
APPLY INITIAL CONDITIONS TO RULE BASE FOR DISPLAY
DISPLAY INITIAL CONDITIONS WITH GRAPHICS & DIGITAL
PRINTOUT IF DESIRED
ADJUST VEHICLE
MEASURE FINAL VEHICLE CONDITIONS
APPLY FINAL CONDITIONS TO RULE BASE FOR GRAPHIC DISPLAY
DISPLAY FINAL CONDITIONS WITH GRAPHICS & DIGITAL
PRINTOUT IF DESIRED
OUT

FIG. 4A

ALIGNMENT VALUE		SPECIFICATION		GRAPHIC
ABS [TOE]	<	1.5 mm/m	⇨	STRAIGHT GRAPHICS POSITION
TOE OUT	>	1.5 mm/m	⇨	TOE OUT GRAPHICS POSITION 1
&	<	3.0 mm/m	⇨	TOE OUT GRAPHICS POSITION 1
TOE OUT	>	3.0 mm/m	⇨	TOE OUT GRAPHICS POSITION 2
TOE IN	>	1.5 mm/m	⇨	TOE IN GRAPHICS POSITION 1
&	<	3.0 mm/m	⇨	TOE IN GRAPHICS POSITION 1
TOE IN	>	3.0 mm/m	⇨	TOE IN GRAPHICS POSITION 2

FIG. 4B

GRAPHIC ILLUSTRATION	LEFT WHEEL	RIGHT WHEEL	AXLE
REF. 1 (FIG. 5A)	STRAIGHT POSITION	STRAIGHT POSITION	STRAIGHT POSITION
REF. 2 (FIG. 5B)	TOE OUT POSITION 1	STRAIGHT POSITION	AXLE LEFT POSITION 1
REF. 3 (FIG. 5C)	TOE OUT POSITION 2	STRAIGHT POSITION	AXLE LEFT POSITION 2
REF. 4 (FIG. 5D)	TOE OUT POSITION 2	TOE IN POSITION 1	AXLE LEFT POSITION 3
REF. 5 (FIG. 5E)	TOE OUT POSITION 2	TOE OUT POSITION 1	AXLE LEFT POSITION 4
REF. 6 (FIG. 5F)	TOE OUT POSITION 1	TOE OUT POSITION 1	STRAIGHT POSITION
REF. 7 (FIG. 5G)	TOE OUT POSITION 2	TOE IN POSITION 2	AXLE LEFT POSITION 6

FIG. 5A

REF. 1

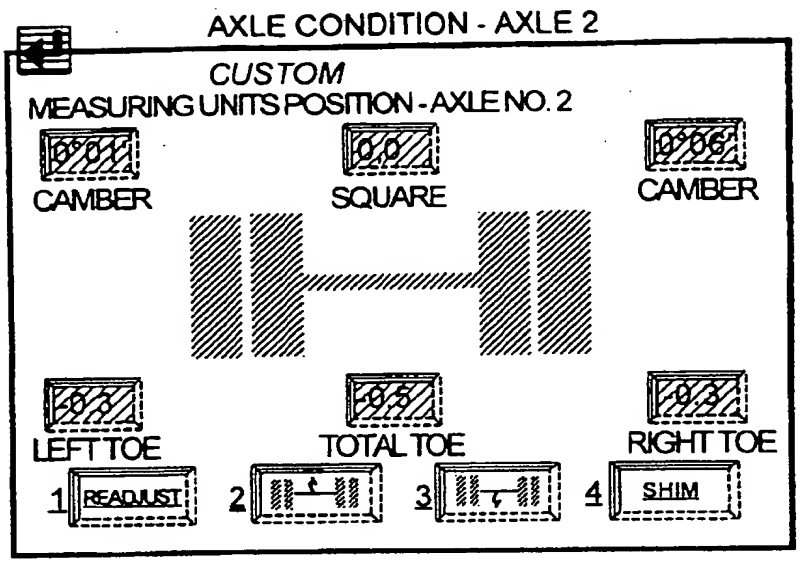


FIG. 5B

REF. 2

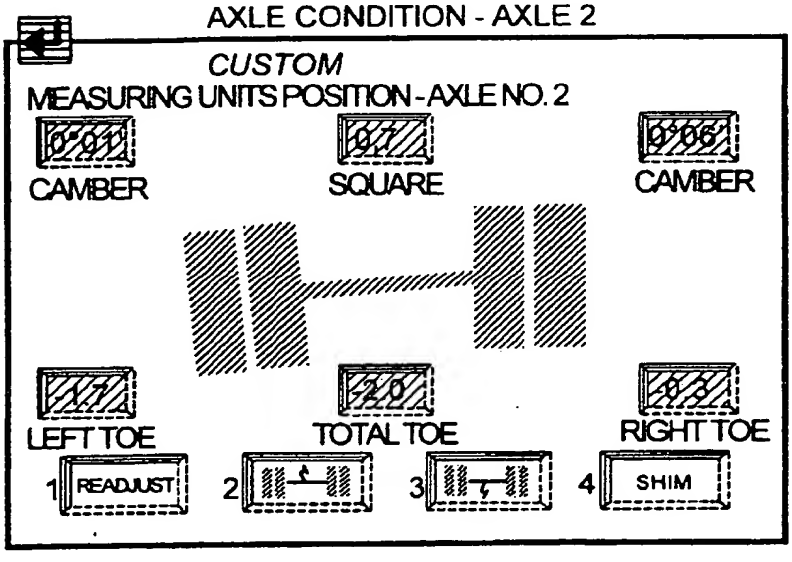


FIG. 5C

REF. 3

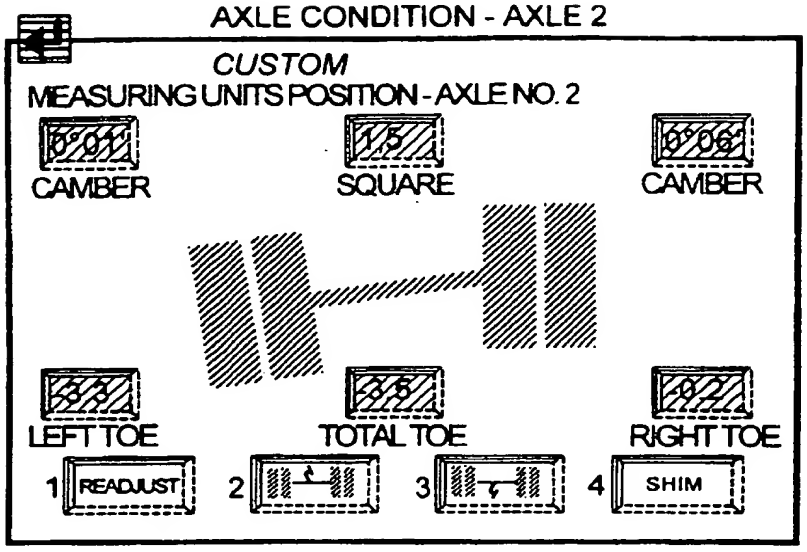


FIG. 5D

REF. 4

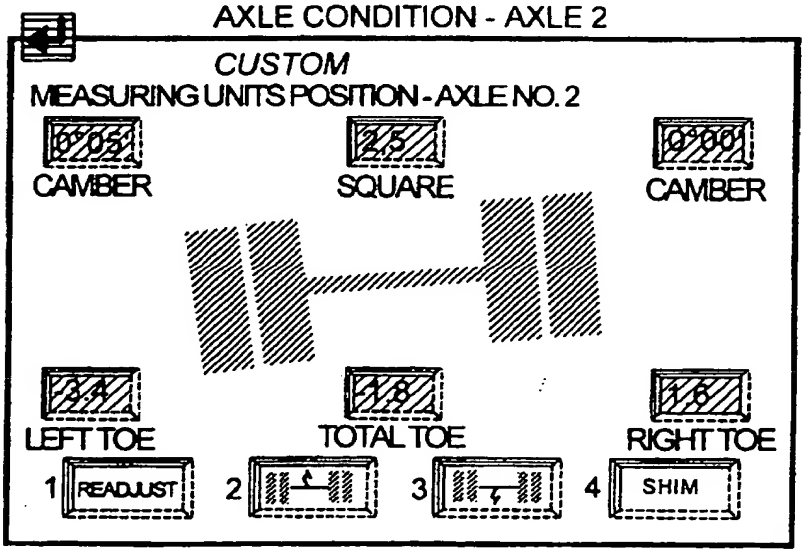


FIG. 5E

REF. 5

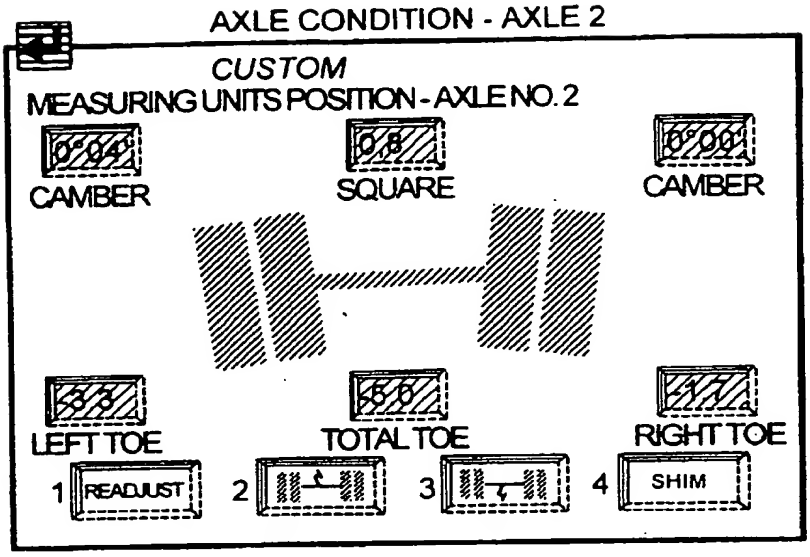


FIG. 5F

REF. 6

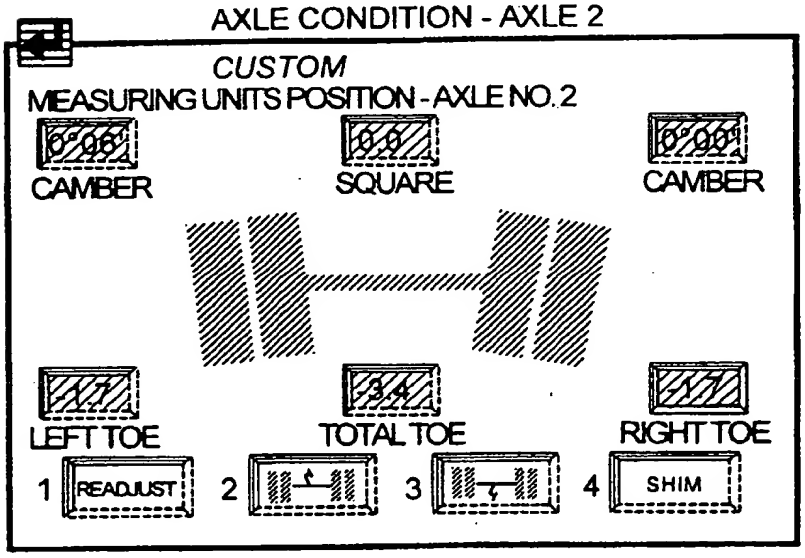


FIG. 5G

REF. 7

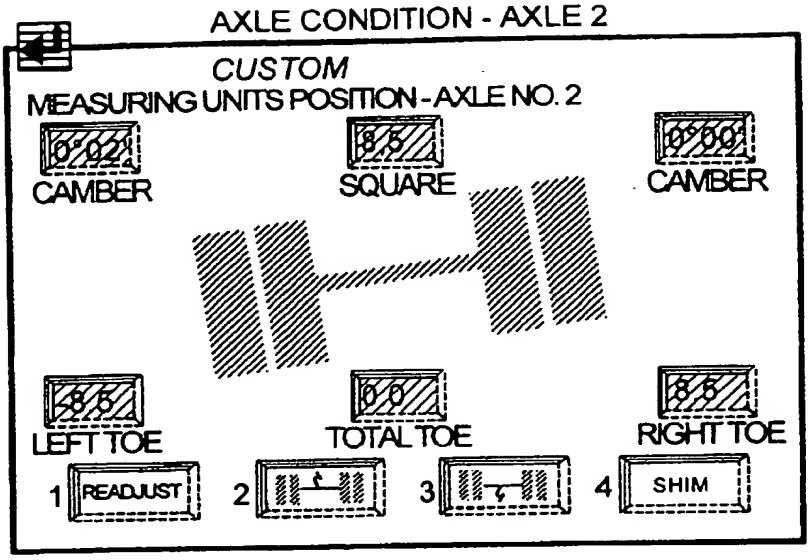

AXLE CONDITION - AXLE 2
CUSTOM
MEASURING UNITS POSITION - AXLE NO. 2
0°02'
CAMBER
8.5
SQUARE
0°00'
CAMBER
8.5
LEFT TOE
0.0
TOTAL TOE
8.5
RIGHT TOE
1
READJUST
2
3
4
SHIM

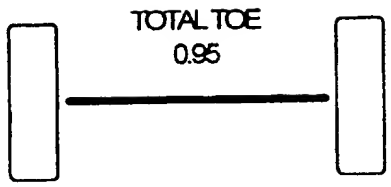
FIG. 6A

CUSTOMER: ORDER:

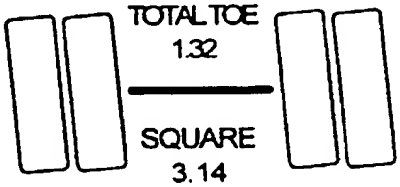
TECHNICIAN:
DATE:
MAKE: MODEL:
REGISTRATION NO.:
CHASSIS NO.:
ODOMETER:

INITIAL TRUCK ALIGNMENT REPORT

TOE OUT ON TURNS	MAX TURNS		MAX TURNS	TOE OUT ON TURNS
2°04'	---		---	2°05'



CAMBER	LEFT TOE		RIGHT TOE	CAMBER
-0°06'	0.69		0.26	-0°06'
CASTER	KPI		KPI	CASTER
3°58'	7°54'		7°58'	4°18'

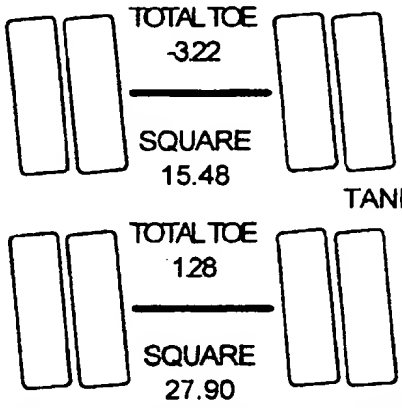


CAMBER	LEFT TOE		RIGHT TOE	CAMBER
-0°04'	-2.47		3.80	-0°03'

FIG. 6B

CUSTOMER: ORDER:
TECHNICIAN:
DATE:
MAKE: MODEL:
REGISTRATION NO.:
CHASSIS NO.:
ODOMETER:

INITIAL TRUCK ALIGNMENT REPORT



CAMBER	LEFT TOE			RIGHT TOE	CAMBER
-0°25'	-17.09			13.87	-0°01'
		TANDEM PARALLELISM -12.42			
CAMBER	LEFT TOE			RIGHT TOE	CAMBER
-0°13'	-27.26			28.54	0°12'

FIG. 6C

DATE: PAGE 1 OF 1
CUSTOMER: ORDER:

TECHNICIAN:
MAKE: MODEL:
LICENSE NO.:
ODOMETER:
REASON FOR ALIGNMENT:

INITIAL TRUCK ALIGNMENT REPORT